Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST ANDREW'S JUNIOR COLLEGE
2022 JC2 Weighted Assessment 2

H1 BIOLOGY **8876**

STRUCTURED QUESTIONS

30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
All working for numerical answers must be shown.

Conceptual error (C)	Data Quoting (D)	Expression (E)	Misreading the question (Q)

For Examiner's Use	
STQ 1	/9
STQ 2	/11
Total	**/20**

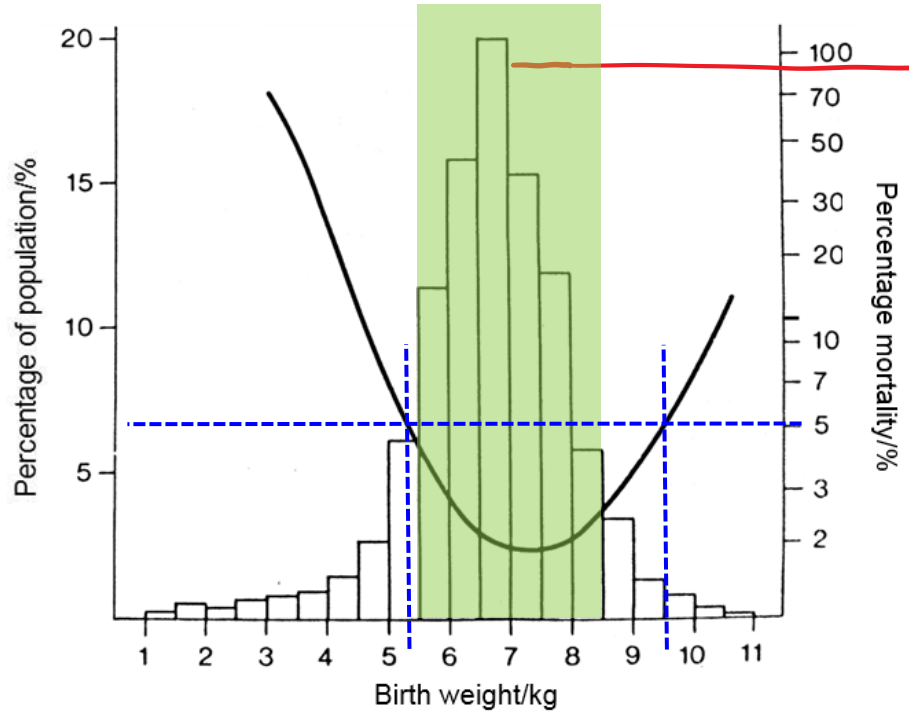
This document consists of 5 printed pages.

[Turn over

QUESTION 1

The diagram below represents the various birth weights of new-born calves in a wild population of deer in the African grasslands. The line graph on the diagram represents mortality in relation to birth weight.

Fig. 1



Intermediate phenotype at high frequency due to low mortality%

(a) Using the information provided in Fig. 1 *(quote data from the graph)*, account for *(state and explain)* the mode of selection acting on birth weight of new-born deer calves.

..... [3]

1 **Stabilising selection**;
2 Calves with extreme birth weights lower than 5.5 kg or more than 9.5 kg [Accept 4.5-5.5kg, and 9.0-10.0kg] have high mortality of >5%, [Accept 3-7%, according to quoted data] and are hence selected against / have lower reproductive success.
3 Calves with intermediate birth weight of 5.5 to 9.5 kg have mortality rate of < 5%, and are hence selected for / have higher reproductive success.

(b) Birth weight of new-born deer calves is an example of continuous variation *(#TB to continuous/discontinuous variation under the topic of genetic basis of variation)*. Explain why there is a variation of birth weights in the population of deer. *(Suggest 4 causes of continuous variation)*

..... [4]

1 **Spontaneous mutations;** lead to **formation of new alleles / genetic variation** in the population.
2 During prophase I, crossing over occurs between homologous chromosomes, the formation of new combinations of alleles on the chromosomes of the gametes;
3 During metaphase I/ II, **independent assortment** of homologous chromosomes/ chromatids, resulting different combinations of maternal and paternal chromosomes;

4 **Random fusion of gametes during fertilization,** giving rise to new combinations of alleles in the offspring.
5 Effect of polygenes (birth weights affected by cumulative effects of different genes);
OR Additive effects of multiple alleles;
6 Ref. to environmental factors affecting phenotype

(c) Suggest why percentage of mortality is higher on **both ends** *(explain the cause of death for both extremes)* of the range of birth weights of new-born deer calves.
…… [2]

1 New-born calves of low birth weights are **more likely to die** due to premature birth / tend to be **under-developed**.
2 New-born calves of **high birth weights** have more difficulty passing through the birth canal and are **more likely to die**/suffocate during birth.

[Total: 9]

QUESTION 2

9744/2017 P3

The rare genetic disease phenylketonuria (PKU) is inherited in an autosomal recessive manner *(need two copies of the mutated PKU allele to have the disease)*. The disease can be detected soon after birth and can then be treated by feeding the baby a modified diet, which is low in the amino acid phenylalanine and supplemented with the amino acid tyrosine.

Table 1.1 shows the frequency of newborn babies who test positive for PKU *(homozygous recessive for mutated PKU allele)* in different areas of the world.

Geographical area	Climate	the frequency of newborn babies who test positive for PKU
Northern Europe	Cold, wet	1 in 10,000
South East Asia	Hot, wet	1 in 60,000
Scandinavia	Cold, dry	1 in ……
Sub-Saharan Africa	Hot Dry	1 in 100,000

(a) In Scandinavia, 1 in 140 people are carriers (i.e. Aa) of the PKU allele.

Complete Table 1.1 by calculating the frequency of newborn babies positive for PKU (*homozygous recessive for mutated PKU allele)* that would be expected in Scandinavia.

You should show your working.
…… [2]

As the frequency of PKU positive individuals is very low, hence the probability of two homozygous recessive individuals mating (aa x aa) and a homozygous recessive individual mating with a heterozygous individual (aa x Aa) is very negligible. Hence we can ignore the probability of that in the working.

Probability of two heterozygous individuals mating
= 1/140 x 1/140
= 1/19600

Aa x Aa → 1 AA : 2 Aa : 1 aa

Probability of a child from 2 heterozygous individuals being positive for PKU
= ¼

Frequency of newborn babies positive for PKU
= 1/19600 x ¼
= 1/78400

Therefore, answer is 1 in **78400**

Examiner's comments:
Not all candidates could combine the probability of two carriers having a child with the expected offspring ratio from such a cross, to calculate the frequency of new-born babies testing positive for PKU. For many candidates, this two-step exercise in logical numerical thinking was straightforward.

(b) The difference in frequency of PKU in different parts of the world may be due to environmental conditions. In wet climates *(so according to table 1.1 in Northern Europe and South East Asia)*, some species of fungi can grow on stored grain and produce a toxin, ochratoxin A.

- Eating ochratoxin A increases the chance of developing renal cancer *(acts a selection pressure)*.
- Heterozygote carriers of PKU have some resistance to ochratoxin A *(heterozygote advantage in natural selection)* and, compared to individuals without the PKU allele *(homozygous dominant)*, are less likely to develop renal cancer (*heterozygotes are selected for by the selection pressure)* if they ingest the toxin.

Explain how evolution could have resulted in PKU being more common in the Northern European population compared to that of sub-Saharan Africa.

…… [5]

1 Sub-Saharan Africa has a **dry** climate while Northern Europe has a **wet** climate. Thus, fungus that produces ochratoxin A **only grows in N. Europe** but not Sub-Saharan Africa.

Evolution via Natural selection

2 Northern Europeans have a **higher probability of consuming ochratoxin A** and hence are at a **greater risk of developing renal cancer** than sub-Saharan African population.
3 Individuals who are **heterozygous for the PKU allele** are at a **selective advantage** in N. Europe as they have some **resistance** against the toxin while homozygous individuals without the PKU allele do not have resistance.
4 Heterozygotes in this region can **survive and reproduce better** to **pass down the PKU allele** to their offspring,
5 resulting in **the increase in frequency of the PKU allele in the population.**
6 This heterozygote advantage is **not present** in sub-Saharan Africa due to the **absence of the fungus as selection pressure due to the dry climate**, hence carrying the PKU allele does not confer any selective advantage.

Examiner's comments:
Few responses made explicit reference to natural selection, but many correctly identified the selection pressure, the genotype of the individuals selected for and the effect this had on the frequency of the PKU allele in Europe. Some candidates were not specific in distinguishing adequately between genotypes and did not use the appropriate term, allele, where it was relevant in their descriptions.

(c) A student wrote, "Individuals in Europe have evolved to carry the PKU allele as seen by the higher occurrence of PKU there." Explain why he is wrong.
…… [4]

1 Individuals **cannot change their genotype** (or alleles) in response to environmental changes.
2 Any phenotypic changes an individual acquired during its lifetime is not passed on to its offspring, hence the **allele frequency of the gene pool to which the individual belongs is unchanged.**
3 Populations are the smallest unit that can evolve.
4 This is because **variations exist** between individuals and natural selection favors some individuals over others. As such, the **favourable alleles become more common** one generation to the next and vice versa.
5 This **change in allele frequency in a population is evolution**.

[Total: 11]